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Journal of the International Carnivorous Plant Society

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Front Cover: *Pinguicula laueana*, article on page 126. Photo by Ron Parsons.

Back Cover: Shawn and Jay, article on page 122. Photo courtesy Margaret Norton, *The Tonight Show*.

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Drosera anglica Huds. vs. *Drosera* × *anglica*: What Is the Difference?

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Keywords: evolution, taxonomy: *Drosera anglica, Drosera* × *anglica, Drosera linearis* × *Drosera rotundifolia.*

Received: 1 March 1999

Summary

Drosera anglica Huds. is of hybrid, amphiploid origin (*Drosera linearis* Goldie and *D. rotundifolia* L. being the parents) and generally is not difficult to identify in its largely circumboreal distribution. However, in the northern Great Lakes region of North America where *D. anglica* occurs sporadically with *D. linearis* and *D. rotundifolia*, problems occur when hybrids (*D.* × *anglica*) and the true species may be sympatric. Furthermore, there is evidence that amphiploidy and therefore speciation is ongoing in the area. A discussion of the origin of *D. anglica,* some ecologic factors, problems with identification, and finally suggestions for distinguishing between the species and hybrid is presented.

Introduction And Background

Drosera anglica Huds. is a north temperate to circumboreal species that can be found in appropriate habitat in much of the northern tier and some sub-tier of the United States and in southern Canada, extending into Eurasia as far south as southern Europe (Schlauer, *in litt.*), and into Japan and the Hawaiian island of Kauai (Diels, 1906; Wynne, 1944). There has been some nomenclatural confusion in the past with *D. longifolia* being used at times either synonymously or in precedence. The latter has been recently resurrected in one flora and Cheek (1998) has applied for rejection of *D. longifolia* altogether (see the cited paper for a detailed history and reasons for suggested rejection). I will use what I also regard as the preferred combination, *D. anglica.*

The presence of the species on the Alakai Swamp on Kauai in the Hawaiian archipelago is of interest (Mazrimas, 1987; Gon, 1994; G. Newman, *in litt.)* since the species is considered northern and Hawai'i is generally tropical. In fact the bogs in which the plants occur are at 1200 to 1800 m (4000 to 6000 feet) elevation.

Therefore, the local climate is not truly tropical in these specific locations. There is no actual frost as there is in wintertime abundance in the more common *D. anglica* habitat, but nocturnal winter temperatures often descend to just above freezing, and summer nights are cooler as well. Approaching winter dormancy in northern continental habitats, the plant forms a tight winter bud (hibernaculum) at ground level. This does not occur on Kauai, but during partial dormancy new leaves are far shorter and atypical in appearance. The plants are also generally smaller in this location and the smaller size and winter behavior are a constant in plants grown from seed in temperate North America.

This article will concentrate on *D. anglica* as it is found in the northern Great Lakes region of North America, particularly in northern Michigan (including the upper peninsula). This area is of interest because there is strong evidence that the species is of hybrid origin and this is the only area where the putative parents, *D. linearis* Goldie and *D. rotundifolia* L., can be found easily with *D. anglica* (not uncommonly in the same fen) (Wood, 1955; personal observation). Interestingly, other hybrids may be found including *D.* × *obovata* (*D. anglica* × *D. rotundifolia*) rarely, and even the hybrid between *D. anglica* and *D. linearis* recently has been identified in nature (Schnell, 1995a). Finally, the hybrid *D.* × *anglica* is also found and this can create immense confusion. So seemingly difficult are *D. anglica* and *D.* × *anglica* to tell apart that Voss, in his recently completed Michigan Flora (Part II 1985), has decided that all the *Drosera anglica*-like plants in Michigan should be referred to as *D.* × *anglica* for simplicity's sake. Of course, this conclusion should not be applied in areas where *D. anglica* and *D. linearis* are not sympatric since *D.* × *anglica* would be impossible in that situation. I hope to show that the two can be discerned, even in the field, where *D. anglica* and *D.* × *anglica* are sympatric.

The species and hybrid in the area we will be discussing occur in a habitat best described as a marl fen (Figure 1; see also description and photos in detail in Schnell, 1980, 1982). Scattered across most marl fens in this region one finds variably sized hummocks of sandy peat and *Sphagnum* mosses (Figure 2). These little islands in the very wet sandy, marly peat of the fen may vary from centimeters to several meters across, the latter supporting shrubs and small trees. The fens are generally surrounded by a 'shoreline' of similar constitution as the hummocks, and then dense forest. These hummocks and borders are usually acid in reaction while the marl flats are basic to circumneutral. Of the *Drosera* we are considering, *D. linearis* grows preferably in shallow water (1-2 cm) over the marl flat, although occasional plants can be found growing on the hummocks and even on wet, decaying logs. *Drosera rotundifolia* grows most often on the tops of hummocks and above waterline on the sphagnous fen margins. *Drosera anglica* and *D.* × *anglica* usually can be found at the bases of hummocks or fen margins, at or near the waterline—an intermediate position. After careful searching, I have found that most of the upper Michigan fens have at least a few to relatively many *D.* × *anglica* and fewer contain *D. anglica,* but those that do often have them in abundance. The latter are found more easily in the many fens of the eastern half of the upper peninsula.

We must consider some of the breeding activity of these *Drosera*. In habitat, the plants begin flowering more or less synchronously in late June to early July. There is a raceme of flowers on the flower stalk (peduncle) and these open and close daily in succession. Each flower opening that day does so by mid-morning (if a bright, sunny day) and then closes by mid-afternoon, and that is it for that particular flower. If a still unknown pollinating agent has not acted in that brief time, the flower undergoes self-pollination as the petals close and press the pollen-bearing anthers against the stigma. Thus, seed is assured, even if not cross-pollinated. The seedpods rapidly expand to 3-4 mm and yield mature seed by late August into early September.

Figure 1: Aerial view of northern Michigan fen. Note interstate highway above. Aerial survey is a good way to identify sites for later surface study.

Figure 2: Typical marl flat in a northern fen with a small hummock. *Drosera linearis* is scattered thinly over the flat. The hummock has *Sarracenia purpurea* subsp. *purpurea* and a few bright green *Pinguicula vulgaris*.

Also to be considered is the fact that hybrids or all North American *Drosera* are sterile (Wynne, 1944; Wood, 1955; Cheek, 1993; Schnell, 1995b). The hybrids cannot breed with each other or the parents, in contrast to the well known opposite situation with *Sarracenia,* for example. In fact this sterility rule can be used as evidence in certain taxonomic problems, such as determining whether *D. filiformis* var. *filiformis* and *D. filiformis* var. *tracyi* should be considered as varieties of one species or two separate species. Since the hybrid between the two is quite fertile, this points to an infraspecific placement, as it is usually classified (Schnell, 1995b).

In 1955, Wood detailed a compelling argument for the hybrid origin of *D. anglica.* Noting that the species had a chromosome count of 2n=40 whereas all other northern *Drosera* were 2n=20, he hypothesized that chromosome doubling had occurred in a hybrid in order to overcome the sterility barrier in northern *Drosera* hybrids. (Those unfamiliar with the n, 2n and x chromosome number designations as well as meiosis vs. mitosis may wish to consult the appropriate chapters of a basic biology or botany text.) Working out of the Douglass Lake University of Michigan Biological Station, he studied the *Drosera* of several bogs and fens in Michigan over several years. He noted the presence of *D. anglica* as well as *D.* × *anglica* in several locations and deduced that the parent plants were likely *D. linearis* and *D. rotundifolia* based on sympatry and morphology.

How does a sterile hybrid of *D. linearis* and *D. rotundifolia* become a fertile species? Studies indicate that the sterile hybrid chromosome count is 2n=20 as expected, and the same as all other northern *Drosera* species. If one examines the early flower buds of such sterile hybrids by dissecting out anthers and ovaries and doing squash preparations or microscopic sections early in development, one notes that the special kind of cell division at certain stages of the development of pollen and ovules known as meiosis is highly disturbed. Both meiosis and mitosis are a precise sort of genetic dance in which chromosomes pair, divide and then disjoin in a highly even manner to produce new nuclei. But in sterile hybrids, some of the chromosomes lag, divide tardily, and form bridges and fragments resulting in highly abnormal nuclei, all of which can be observed by staining and microscopically examining tissue. It is no wonder that such hybrids are sterile.

However, if some little-understood accident results in retardation of meiosis altogether, fertile pollen and ovules with an unreduced chromosome number occur which can then result in viable embryos and seed. The chromosome number of the seed embryo and resulting seedling and plant has now doubled. This process is known as allopolyploidy, or more often by the synonym amphiploidy (*e.g.* Grant, 1981; Briggs & Walters, 1997). Since the amphiploid plant's chromosomes may now pair up properly with the equivalent from the same contributing parent plant during meiosis, the now amphiploid plant is capable of producing viable seed normally generation after generation. Generally, such amphiploids are then recognized as species rather than hybrids.

This then creates a problem for us in the field where parents, hybrids and amphiploid species occur together: How do we easily tell the amphiploid species from the hybrid in a consistent way? Wood (1955) accomplished this by using chromosome counts of root tip (chosen because of active growth and many mitoses being present) squashed and stained preparations and squashes of developing anthers and ovules. He also determined that the flat surface epithelium cells and stoma guard cells of leaf epithelium differed in size, the species generally being larger in this respect, presumably due to a greater chromosome complement than the hybrid. Because the species had larger cells and nuclei, Wood was able to measure these and separate the plants for his research. Having found and discerned the *D.* × *anglica* hybrid in several northern Michigan fens, he described it, naming it by formula (*D. linearis* × *D. rotundifolia*). But he was not always certain of separating the hybrid and species from each other by inspection of whole plants in the field.

Next, Wood discovered something of great evolutionary interest—the origin of *D. anglica* is apparently polytopic; that is, it has occurred by amphiploidy of the hybrid in more than one place, and this process is probably ongoing. This phenomenon has been noted in several other non-carnivorous genera and species (*e.g.* Wood, 1955; Grant, 1981; Briggs and Walters, 1997). Likely, the unknown stimulus for amphiploidy has worked and is working in several different fen locations. Wood was able to deduce this by noting a very few clusters or single plants of the fertile species in large fens with many thousands of other *Drosera* species and a even a few of their hybrids, and also noting that small populations or individual plants of *D. anglica* (species) were often in fens located many miles apart.

One wonders how *D. anglica* has developed such a wide present day distribution nearly around the world while one of its evolutionary parents, *D. linearis*, has remained so localized to the Great Lakes region (but with a few disjunct populations in the Canadian maritimes and at least one small population in northern Maine (Diels, 1906; Wynne, 1944)). Did *D. linearis* at one time have a greater distribution than at present and is receding into its present redoubt and perhaps further in the future? Marly fens to which *D. linearis* seems confined are very fragile habitats. I have seen several Lake Huron shoreline beach pool fens destroyed in one season by severe winter storms and dune blowouts. Or have plants of *D. anglica* simply been distributed widely away from the present Great Lakes area to pioneer in suitable habitats nearly around the world? *Drosera anglica* is ultimately a much more flexible species in its habitat requirements than *D. linearis* in my observations in the field and in cultivating the material. If distribution is the factor, what were or are the carrying agents? Seed on bird feet, as the postulation of plovers bringing propagules of *D. anglica* from Alaska to Kauai. Or was it the prevailing winds bringing seed from Japan to the Alakai Swamp (Mazrimas, 1987; Gon, 1994)? We do not know.

Differentiating *Drosera anglica* From *Drosera* × *anglica*

I conclude this paper by listing and briefly discussing ways to tell *D. anglica* from *D.* × *anglica*. I will discuss the most technical and complex methods that have been used first, then work down to some more easily accomplished field methods. The most technical procedures are of course most definitive at this time. However, they often require sophisticated equipment and the processes themselves are usually beyond the expertise of even the most dedicated amateur and often many professional botanists. Some molecular biological procedures, such as DNA, isoenzyme and FISH (fluorescent in situ hybridization), have not yet been recorded for this problem, but have good potential, especially FISH.

Highly Technical Procedures

1. Microscopic sections prepared by standard histotechnological methods of developing flower buds with staining to discern cells and features, and looking particularly for developing anthers and ovaries to evaluate meiosis. One searches for abnormal chromosome segregation and homologous pairing with lagging and unmatched chromosomes and fragments (*e.g.* Grant, 1981). Technical help is required for making the slides, and considerable experience in evaluating them under the compound microscope.

2. Microscopic examination of stripped or peeled epithelium of the leaf undersurfaces (to avoid glands) (Wood, 1955). Because of amphiploidy, epithelial pavement and guard cells of stomata in *D. anglica* are larger than those of the hybrid. These cells can be measured by planimetry.

Figure 3. Leaves of *Drosera* × *obovata*.

Figure 4: Average leaves of *Drosera anglica* and *Drosera* × *anglica*. Compare with *Drosera* × *obovata* in Figure 3.

Figure 5: *Drosera anglica* in northern Michigan. Note the thicker peduncles compared to *D.* × *anglica* in Figure 6.

Figure 6: *Drosera* × *anglica* in northern Michigan. Note the more slender peduncles compared to *D. anglica* in Figure 5.

3. Somewhat more accessible than above but requiring manual skill, experience, stains, a compound microscope and often some luck, one can prepare squashes of root tips (where there is a lot of mitosis going on) and even developing anthers and ovaries of dissected flower buds to count and evaluate chromosomes. In this case, we are interested in the 2n=20 vs. 2n=40 status of the root tip cells, and evaluating meiosis in good preparations of the flower parts cells. There is a huge body of scattered literature on how to do this so I will not list it here. We are overdue a current single volume describing the most prominent methods in detail with critiques.

Less Technical Procedures

4. The 'less technical' here is relative since at least one stain and a compound microscope (Do we not all carry one in our vans while in the field?) are required. However, the procedure is not difficult to do and evaluate. Pollen staining is based on the premise that viable or living pollen grains capable of fertilizing an ovum will take up certain stains while many sterile hybrids of plants produce only empty or incompletely staining grains. A good reference for pollen viability procedures is Kearns and Inouye (1993) who evaluate several of the pollen staining procedures and find some lacking and/or little controlled on exactly how useful they are. It is probably relative and some are likely more useful in certain plant groups than others. I have had considerable experience with the stain lactol phenol cotton blue on *Sarracenia* and *Drosera*, using known and unknown hybrids compared to species, and find that it is useful and consistent. One simply dusts a small amount of pollen (do not overdo it or you will exhaust your stain and get false negative grains) on the center of a clean, dry glass microslide, add a drop of the stain, mix the stain and pollen thoroughly with a one-time use toothpick and put a coverslip over the preparation.

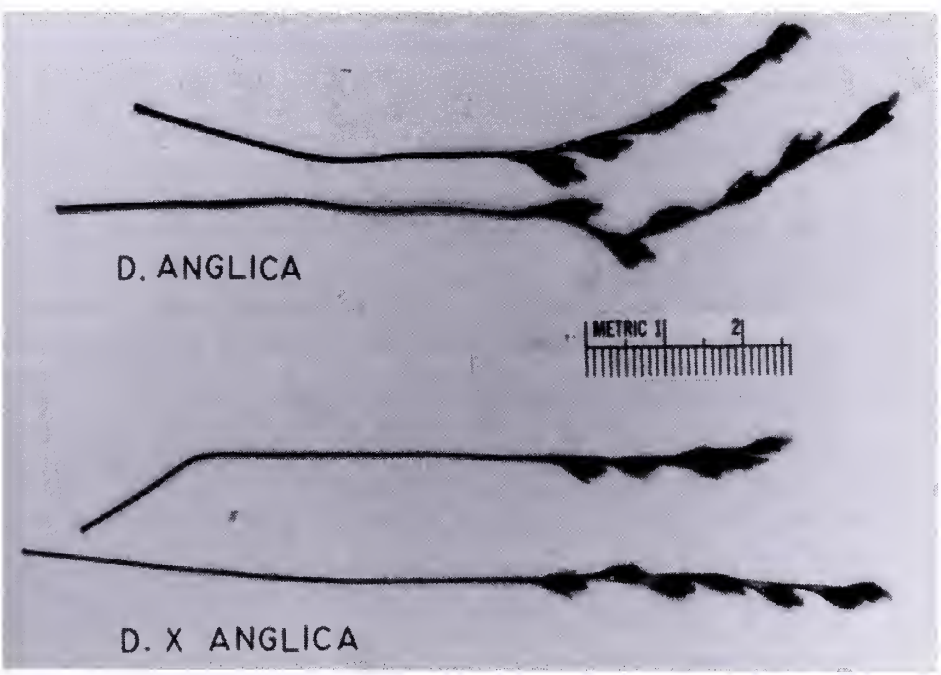

Figure 7: Comparison of late season peduncles with spent flowers of *Drosera anglica* (above) and *Drosera* × *anglica* (below). Besides having peduncles with greater thickness (see text for measurement ranges), *Drosera anglica* also has maturing seedpods.

Viable grains of species and fertile hybrids (e.g. as in *Sarracenia*) stain a deep blue across the entire grain. Grains of sterile hybrids are empty and take no or far less stain. A few hints not mentioned in the usual procedure instructions: After covering your preparation with the coverslip, let it set for about four to six hours for the stain to absorb. Secondly, to get used to what you are looking for, try a few known fertile related species for comparison and also control. Finally, remember nothing is 100% in testing. There will be some (usually less than 5%) empty grains in perfectly fertile species, and a very few grains staining positive in sterile hybrid preparations.

Procedures More Adaptable For Field Use

5. The next consideration is leaf shape. In his 1955 paper, Wood states that *D. anglica* and *D.* × *anglica* cannot be distinguished in the field by leaf shape, but a page later goes on to say that the leaves of *D.* × *anglica* have more the shape of another hybrid, *D.* × *obovata* (*D. anglica* × *D. rotundifolia*)—that is, obovate-spatulate—while the species *D. anglica* is linear-spatulate (Figures 3 and 4). Actually, both statements are true! On average when examining many leaves of many plants, the hybrid *D.* × *anglica* is indeed distinguishable from *D. anglica* (as is the case when pulling three representative leaves of each taxon for Figure 4 out of hundreds collected and pressed). But as is often the case in statistical situations, there is overlap in single cases and individuals may present a problem. To further confound the situation, *D.* × *obovata* is occasionally found with our two problem taxa in the same fen. Usually, when you find only a few widely scattered or small clumps of anglica-like plants in a fen, you are more likely dealing with *D.* × *anglica* since when *D. anglica* is present, it is usually in relatively large clumps and/or numbers. Leaf shape can be helpful but its limitations must be appreciated.

6. One can take advantage of the fertility of the species and the sterility of the hybrid to observe whether *Drosera anglica*-like plants have maturing seedpods, and even collect seed to compare with the fine Wynne (1944) drawings. If you are bogging in the spring or early summer before seedset, you can flag your plants and examine them later in the season.

7. I have noted that the species has a consistently larger corolla than the hybrid, similar to the epithelial cell sizes mentioned in item 2 above. *Drosera* × *anglica* measures 6-7 mm across, while *D. anglica* is 8-10 mm. This is very useful if you catch the plants in flower.

8. Comparable to item 7 above, the peduncles or flower stalks are of different thickness (see Figure 5,6,7): The hybrid consistently measures 1.0-1.2 mm in thickness while the species is 2.0-2.2 mm. This is also very helpful.

In summary, what do I do? Technically, I do indeed use pollen viability studies on occasion. Leaf shape is also very helpful when correlated with other factors and taken in perspective. Of course, seed production is quite definitive in the field and horticulturally. But I have found that there are flowers and/or peduncles nearly all summer, and sizes of these are the most helpful.

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Special Reviews: Videos by Hartmeyer Productions

In recent issues of Carnivorous Plant Newsletter (26:2, 27:4) and on the internet, there have been occasional references to two videos produced by Siegfried and Irmgard Hartmeyer. I contacted the Hartmeyers, and they were good enough to provide copies for the ICPS to review.

Both videos (Beautiful & Hungry—Carnivorous Plants, parts I and II) are travelogues that follow the Hartmeyers as they journeyed through Singapore, Australia, Germany, and Switzerland. While both videos have all the charm of home movies, the second is probably more interesting to the dedicated carnivorous plant grower. Less time is spent on holiday activities like scuba diving and parasailing, and more on carnivorous plants. Particularly interesting is this video's devotion to arthropods that live on sticky plants and dine on the unfortunate prey trapped by the adhesive leaves. These arthropods and their associated plants are shifting and blurring the distinctions between carnivorous and non-carnivorous plants.

In the making of both videos, the Hartmeyers encountered bizarre and unfortunate circumstances that prevented them from finding all the plants they hoped to see. To compensate for this, they show plants from their own collections.

It may be difficult for many ICPS members to view the Hartmeyer videos because of videotape incompatibilities (for example, the US videoplayers are unable to play these European videos). However, interested parties should contact the Hartmeyers at Wittlinger Str. 5, D-79576 Weil am Rhein, Germany, email: S.Hartmeyer@t-online.de. The Hartmeyers plan to produce future products on more universal, digital formats. (BAMR)

The Savage Garden

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Keywords: chemistry — cultivation: *Dionaea muscipula* — observations: *Sarracenia.*

Venus Envy

Quite often at our nursery, visitors during the height of summer will marvel at the size of some of our display Venus Flytraps. While some of these plants have been in our collection for many years, even newly added ones—sometimes taken from our sales table—soon have traps considerably larger than they originally were.

The reason for this is simple. Rude fingers! Despite our signs begging, "Please do not tease the plants," there is something irresistible to those unfamiliar with this most famous carnivorous plant. They want to see the trap snap shut, and sign or no sign, they cautiously tickle the interior of the leaf and then squeal in delight at the sudden response. Of course, visitors who tease Venus Flytraps rarely buy the plants. And despite our policy of BYOB (Bring Your Own Bugs) and welcoming visitors to feed as many plants as they wish, provided they bring their own insects (we do supply forceps), most of these folks want instant gratification and do not want to hassle with stepping outside the greenhouse to rummage under logs and leaves to find a sowbug or two. So with stealthy behavior they stick their finger into a trap, triggering it empty. Then they usually spring one or two more. This misbehavior is particularly vexing when they step over to the sales bench and tease those plants, too. Most buying customers will not purchase a Venus Flytrap when all the traps are closed.

Of course, the folks who tease the plants do not realize it, but I think they are the reason our display plants get so big. Every time a trap is sprung, it gets larger. When two trigger hairs are touched, or one hair twice, an electrical stimuls causes the cells on the outside of the trap's lobes to stretch simultaneously. As the empty trap slowly reopens the next day, the cells on the inside of the lobes grow and stretch. The end result is a slightly larger trap every time the trap is sprung. Added to this the frequent meals the plants get, and the end result is larger and more vigorous plants. But the one disadvantage about teasing traps to get them bigger is that they can only close about six to ten times, after which they cease to function, turn black, and die.

Several years ago Joe Mazrimas told me an interesting story. He said there was a fellow who had won a blue ribbon in the early days of the San Francisco Flower Show for the biggest Venus Flytraps Joe had ever seen. "They were gigantic!" Joe exclaimed. "More like mousetraps than flytraps!" I asked Joe if he found out the secret of the grower's success, and Joe smiled slyly and told me the punchline.

"Every day or two he would stimulate only one trigger hair in each of the traps, without closing it," Joe explained. Apparently, the stored action potential, unreleased by a second stimulus, was enough to cause the cells to stretch slowly and grow. The result, awarded with a blue ribbon, was the envy of all who attended the show.

(Could this be true? I am skeptical, but I am already designing an experiment to test it!—BAMR)

One of the most intriguing things about *Sarracenia* is the effect of their nectar on insects. As those of us who grow the plants know, an insect who lands on a trumpet leaf and begins to feed on the nectar immediately loses much of its inhibition. The reaction is so instantaneous that one can only conclude that the nectar surely must taste good! While a housefly feeding on sugar or honey will quickly be startled by the shadow of an approaching hand, that same fly on a pitcher plant will sit and drink until a finger practically touches it. Even when it finally buzzes away, it often returns to the same spot in seconds.

The drug coniine has been isolated from the nectar and leaves of *Sarracenia purpurea* and *Sarracenia flava*, and this chemical is known to paralyze and kill small ants within minutes (see: Mody, N. V., Henson, R., Hedin, P. A., Kokpol, U., & Miles, D. H., 1976, Isolation of the Insect Paralyzing Agent Coniine from *Sarracenia flava*, Experientia (Basel) 32, 829-830). Sometimes I have seen dead ants in the hairs on the collar of purple pitcher plants. Some have theorized that fumes released by these pitcher plants are enough to intoxicate them.

I once had the unexpected pleasure of watching the complete effect of coniine on ants. Actually, it was not pleasurable at all, and has haunted me for many years! It is something you can duplicate and watch yourself, should you be so inclined. All you need is a healthy *Sarracenia flava*, an ant trail, and a magnifying glass.

My own observations came by accident. I had moved a yellow trumpet plant to my work bench of the greenhouse with the intention of later transplanting it. A pitcher leaf broke at the base in the process (it was snagged by a *Nepenthes* tendril) and the result was this lovely new trumpet toppling over, still attached to the rhizome. The lid and mouth area were now laying on the bench, virtually upside down.

The next day as I prepared to transplant it, I noticed the whole plant swarming with ants—a not uncommon thing. But what immediately caught my eye was the literal pile of dead ants on the bench where the broken trumpet lay. "Coniine in action!" I thought. Since the leaf was upside down, the ants feeding on the copious nectar were falling to the bench instead of down a normally upright tube. I was really startled at the number of dead ants, which must have numbered in the hundreds.

I grabbed my magnifying glass, and then a more power micro-lens, to get a better view of this horror. What I saw kept me transfixed at the spot for nearly an hour.

Ants that were feeding on the nectar fell, one by one, to the bench for an obvious reason. It was quite apparent that their legs were affected first. They would fall and quickly roll onto their backs, their legs literally crumpled above them. Their heads and abdomens wildly thrashed, antennae twitching furiously. But they were completely helpless, their legs folded up and not moving.

Healthy ants just arriving on the scene, following the trail of ant pheromones to the source of food, seemed quite concerned as to what was happening to their comrades. Their antennae inquisitively probed the stricken ants' bodies from "head to toe," so to speak. Sometimes two or three healthy ants scurried about one ill ant, as though they were deeply concerned.

I watched as all the dying ants behaved in the same manner. After the legs crumpled up, the thumping abdomen was the next to become paralyzed. Soon the whole body lay still, except for the head, which twisted and turned, its mandibles

snapping, its antennae flailing about.

Soon the head, too, ceased to move, except for the twitching antennae. In fact on all the ants it was their antennae that were the last to go, feebly jerking and twitching until they, too, stopped.

Many of the healthy ants carried away the frozen bodies of their siblings. Others went on to the deadly nectar and followed the fate of their brethren. It took each afflicted ant about fifteen minutes to half an hour to die. Hideously.

Ah...the joys of carnivorous plant growing.

ICPS World Conference 2000 News: Call for Abstracts

Due to space restrictions, the 2000 conference will not be able to have a poster paper session. However, field and laboratory researchers, horticulturists, conservationists, and other authors can submit a short summary of their recent work for inclusion to the proceedings volume that will be produced by the 2000 conference. This call for abstracts is not limited to conference attendees.

Abstracts should be 400 words or less, no photographs, in English. Electronic submissions are preferred, but clear computer/typewriter copy (12 pt, Times font) is acceptable. Include an abstract title, your name, and your mailing address. Send your abstracts to David O. Gray, Conference Registrar, 584 Castro St. # 687, San Francsisco, CA 94114 or via e-mail (davidogray@aol.com).

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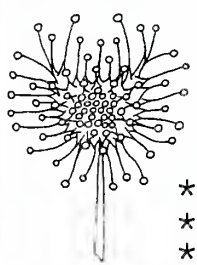

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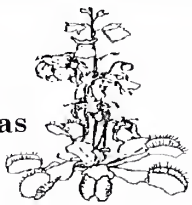

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Drosera meristocaulis: An intriguing sundew from South America

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Keywords: observations: *Drosera meristocaulis*.

The unusual *Drosera meristocaulis* resides on the summit of Cerro de la Neblina, a tepui of southern Venezuela (0° 54.5' N; 66° 2.5' W). This stem-forming species superficially resembles *D. neocaledonica*, but the floral details place it in its own subgenus. A brief description, based on herbarium study, is given below.

The New York Botanical Gardens has led several scientific expeditions to the species-rich regions of tropical America, and during a 1953-54 expedition to Venezuela, Cerro de la Neblina was climbed and explored. Amongst the botanical treasures seen was an unusual species of a stem-forming sundew. This species was named and described *Drosera meristocaulis* by Maguire and Wurdack in 1957. An additional herbarium collection of it was made in 1985.

The plants form vertical, variably branched stems up to 150mm tall. Adventitious roots grow through the column of retained dead leaves, and this tangle of roots becomes exposed in herbarium specimens as old leaves fall away. It is not known if this also happens in the wild. The growing point at the apex of each stem bears a semi-erect rosette of spathulate leaves. The leaves are as long as 16mm long, and consist of glabrous, linear petioles up to 12mm long, and oblanceolate lamina which are up to 4mm long by 1mm wide. The rosette centres are conspicuously hairy due to a silvery white stipule at the base of each leaf. Each stipule is approximately 10mm long, and is divided almost to the base into many filiform segments (Figure 1).

Based on the presence of fruiting capsules near the growing point of many of the herbarium specimens seen, it appears that this species flowers in December. The architecture of the flowers characterises this species. The solitary flowers are produced on such short pedicels that they are almost sessile. The three styles are undivided, which in the genus *Drosera* is a feature shared only with the palaeoendemic *Drosera regia* (Schlauer, 1996).

According to notes on the herbarium sheets, *Drosera meristocaulis* is locally frequent between 1900m and 2200m altitude in open bog savannas, in *Heliamphora neblinae* swamps, and along streams with *Euterpe*. It is interesting that specimens collected near the summit of Cerro de la Neblina often have several different lichens on the dead leaves below the active rosettes. These include colourful small red cupped lichens, small yellow disc lichens, and irregularly-oval white lichens.

A number of speculations are warranted on the pollination of this species. Whilst the open pink-petalled flowers are relatively large at approximately 20mm across, they are located within the morass of actively trapping leaves—a juxtaposition unique in the genus. It appears reasonable that this species is pollinated by large-sized flying insects which are too large to become ensnared by the many small trapping leaves.

Little is known about this species. Since its initial description it has remained in obscurity, and only snippets of information are on the few herbarium sheets stored at locations on both sides of the North Atlantic. The study of live plants would provide valuable information on this apparently archaic species, and would shed light on the evolution of the genus. From field notes and the specimens seen, it has horticultural appeal, although it is difficult to visit its only habitat (see the article on page 122!). It is unlikely that *Drosera meristocaulis* is yet in cultivation, but it would probably grow as easily as *Heliamphora*.

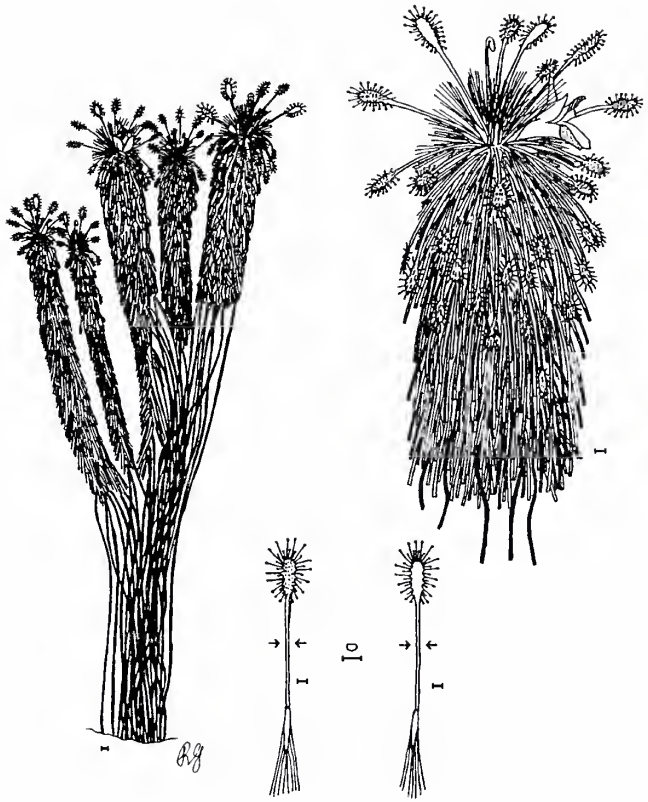

Figure 1. *Drosera meristocaulis* from the isotype herbarium sheet B. Maguire, J.J. Wurdack and G.S. Bunting 37133. Collected January 5, 1954, and now housed at the British Museum (Natural History) in London. A mature plant is shown, with enlarged examples of a rosette and both sides of a leaf. Note the calyx amongst the semi-erect rosette leaves and the much divided stipule. Scale bars=1mm.

In conclusion, *Drosera meristocaulis* is an interesting species due to its unusual features and its relative obscurity. Whilst its future in the wild seems assured due to difficult access and no population pressures, it would be wonderful to one day see and study live plants in cultivation. It may hold the key to many mysteries about the evolution of *Drosera*.

Acknowledgments

I wish to thank Dr. Roy Vicary and the other friendly staff at the British Museum (Natural History) herbarium; Dr. Martin Cheek and the other helpful staff at the Kew Herbarium; the director and staff at the New York Botanical Gardens Herbarium; and also Matt Hochberg. The success of this overall study would not have been possible without the support of Dr. Neville Marchant, Director of the Western Australian Herbarium.

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Neblina Expedition

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Keywords: travelogue: Brazil.

Between December 1998 and January 1999, a group of carnivorous plant enthusiasts was able to climb the highest mountain in Brazil for the first time. The 3014 m high Pico da Neblina (Portuguese for "Fog Peak") is lost in the middle of the Amazon rainforest, and because of its isolation and inaccessibility only a few botanical expeditions have reached its top—and these were only possible because of helicopters. Andreas Wistuba, Joachim Nertz, and I had long dreamed of and often discussed going to Mt. Neblina to see fantastic carnivorous plants such as *Heliamphora tatei* var. *neblinae* and a "missing link" *Drosera* species called *D. meristocaulis* (see the article on page 120). At the 1998 ICPS Conference in Bonn we finally decided that six months later we would attempt to hike up to Mt. Neblina. We didn't know how to get there, nor even if there was a trail up the mountain. All we had were a few clues, snippets of information from here and there, and rumors. We were not much better off in December, when the eight expedition members finally converged in Manaus.

The expedition truly began with a flight to a small town near the triple-border of Brazil/Venezuela/Colombia (passing over a seemingly infinite green carpet of forest cut by large winding rivers), endless negotiations with 'garimpeiros' (illegal gold prospectors—none of which inspired much trust), buying our supplies, organizing transportation and equipment, and bureaucratic trouble with all our permits (including one to collect plants). We secured two guides and three Yanomami Indian porters, and finally began our trip upriver. We passed high green walls of trees on the riverbanks and occasional Indian villages, but saw surprisingly little animal life. Fortunately, the water in the rivers was high, and after chugging along for only two days we reached Mt. Neblina.

Once on land again, we began the next leg of our trek: a 30km, uphill hike through thick, steaming rainforest. But even before starting, an unexpected problem developed: weight! Our guides and porters all of a sudden refused to carry up as much weight as they had promised they would—but none of us could bear to leave anything behind. This problem would haunt us continuously throughout the hike up and down Mt. Neblina and I had a hell of a time arguing with our guides and porters at every rest stop. But there was no solution other than to reluctantly carry more weight than we had planned to. As we climbed higher up the mountain, the exaustion slowly convinced us to shed some of our weight and a trail was formed of small bundles wrapped in plastic bags to be picked up on the return journey.

The rainforest seemed never-ending and I have to admit I was soon quite sick of it. I couldn't wait to set my eyes on some carnivorous plants! Then suddenly, at around 1600 m elevation, there was a surprisingly clear and abrupt transition to cloud forest, and we finally began finding carnivorous plants. Among the moss-covered tree trunks, we first found *Utricularia alpina* with huge white flowers, and then the beautiful orange-red blossoms of *U. campbelliana*.

Another abrupt transition brought us to the more open highland vegetation and large bromeliads were suddenly everywhere, all seemingly infested with *U. humboldtii*. The large light purple-pink flowers of this *Utricularia* were so abundant

that we were soon ignoring them as other carnivorous plants caught our attention. Growing in a peaty, sandy muck were rather unusual-looking *Drosera roraimae* and striking, dark pink-flowered *U. quelchii*.

After a few hundred meters of sinking in that deep muck up to our knees, we reached the summit campsite at 2000 m elevation. But where were the *Heliamphora* and *Drosera meristocaulis*? We thought we would be seeing them everywhere, as soon we reached the high altitude vegetation, but there were no signs of them. Nor did we find any the following day, while hiking in areas near the campsite. While we had our first view of the actual summit of Mt. Neblina, rising dramatically like a giant needle piercing the sky (it reminded me of the Matterhorn, but without any snow), in terms of carnivorous plants we only saw more of the same species we had seen on the previous day. Yet luck had not left us altogether and we did discover a (possibly new) species of *Drosera*, a small rosetted plant that looked like a cross between *D. brevifolia* and *D. montana*.

On our second night at our summit camp, we were all too exausted to drag ourselves out of the tents at midnight to celebrate the arrival of the new year—nor did we have any *Heliamphora* pitchers to drink the champagne we had lugged all the way up the mounatin, as we had planned. The next day, we headed in a new direction and after about an hour's hike, we finally found *Heliamphora*! They just popped up in a habitat that seemed no different from dozens of others we had seen over the previous two days, in boggy, peaty soil semi-shaded by low vegetation.

We later discovered that this plant was common all along the final leg of the trail to the top of Mt. Neblina, where many plants were seen in flower. It even grew above 3000 m, next to the Brazilian flag marking the highest point—making it the highest *Heliamphora* population in the world! (Figure 1)

One site we found with *Heliamphora* was simply incredible. Maybe a plant had gone wildly crestate many years ago, I am not sure. All I know is that hundreds of small pitchers were densely clustered and piled upon each other, forming a mound around 1.75 m high and at least double that across at the base. Numerous other plants were growing on this mound, including *D. roraimae*, and a small tree grew right through it.

On our third day at the summit, the first of the new year, we finally stumbled on a very boggy site with *H. tatei* var. *neblinae*. An area of approximately 200 × 50 m was packed with this species in flower. What fascinated us all, more than the size and beauty of the plants, was their incredible variability. There were all-green to all-red plants; long thin pitchers to short fat pitchers; long tongue-like lids to small rounded lids; stems invisible underground to visible above ground (either lying over the soil or leaning on surrounding vegetation for support and reaching 1.5 m in height!); throat hairs absent, to thin and numerous, to coarse and scarce; and so on. Each clump seemed to be a completely different species! I had to keep reminding myself that some of the larger clones with long lids were not *Sarracenia*! That was the best start of a new year any of us had ever had!

The only other carnivorous plants we found on Mt. Neblina were *U. amethystina* and *U. subulata*. We did not see *Genlisea*, strangely enough, nor did we find *D. meristocaulis*, much to my distress. My last hope was the hike to the summit of Mt. Neblina where I expected to find different habitats and hopefully different carnivorous plants. My hopes were destroyed. Near the top we found a single specimen of *Saccifolium bandeirae* (Saccifoliaceae, Gentianales), a weird plant which was suspected of being carnivorous. But we could find no trace of glands on the underside of its inverted cupped leaves, which reminded me of a young *Cephalotus* in tissue culture.

Four days after beginning the descent of Mt. Neblina we were feasting greedily

on a huge barbecued meal back in civilization ("civilization" being a word that we would never have used to describe that small frontier town, at least not before spending thirteen days in the rainforest!). We had all survived the hike, fortunately with only minor injuries and illnesses. Nonetheless it had been the most exhausting and demanding trip any of us had ever been on. Technically speaking, the final leg of climb to the summit of Mt. Neblina was the most difficult mountain trail I have ever done, and involved quite a bit of rock climbing skills. We later learned that we had hiked up along the northeastern ridge of the Neblina Highlands while previous botanical expeditions had landed their helicopters on the northwestern ridge. This explains why we did not find a single *D. meristocaulis*, which had been reported as common.

Maybe next time...

Figure 1: The exuberant, but sodden expedition at the top of Mt. Neblina, holding innovative champagne servers (*Heliamphora* pitchers). From left to right: Christoph Scherber, Andreas Wistuba, Gert Hoogenstrijd, Joachim Nerz, Fernando Rivadavia. The guide Deco is in the rear, by the Brazilian flag. Photograph by G. Hoogenstrijd.

Carnivorous Plants Hit The Big Time!

Shawn Lyons • 890 S. Abbeywood Place • Roswell, GA 30075 • USA

Keywords: outreach: news media.

When I was four years old, my mom read to me a book called *The Reason For A Flower*. It had a few pictures of carnivorous plants, and I just had to learn more about them. I read all the library books I could get my hands on, and when Easter came the Easter Bunny brought me a butterwort (*Pinguicula primuliflora*) and a Venus Flytrap. Then mom took me to The Chattahoochee Nature Center to meet Henning von Schmeling. He knew a whole lot about carnivorous plants. He gave me some and I grew them really well! Since then I have been reading and studying a

whole lot about them.

I am learning how to take care of ones that are more difficult to grow, like a *Pinguicula* species from Pachuca. I won two blue ribbons at the Southeastern Flower show for my *Utricularia gibba*! I have *U. gibba* because I went to an aquatic plant store to buy some water hyacinths for a plastic basin in my back yard. A year later I noticed there were some plants in my basin that had little bladders on them. I said, "Mom! I think there's a carnivorous plant growing with my water hyacinths!" She said, "That's not possible! You're just imagining carnivorous plants everywhere!" I took some of the plant to show Henning and he said they really were bladderworts. He said those water hyacinths might have come from the wild and maybe had some bladderwort plants or seeds hitchhiking in their roots.

Once I wrote a letter about my carnivorous plants to a TV game show called *Figure It Out*. (It is broadcast by the Nickelodeon Network, and my dad says it is like a kids' version of an old show called, *What's My Line?*) In March 1998, they picked me to be a contestant on the show. I won the grand prize because no one on the panel could guess I grow carnivorous plants. The producers from *Figure It Out* called the producers of *The Tonight Show With Jay Leno*, and on July 15 1998 I was on *The Tonight Show*. I taught a few million people about carnivorous plants!

Instead of flying my plants to Orlando and Burbank for the shows, Henning knew carnivorous plant growers who helped me out. Steve Steward from Orlando let me borrow plants for *Figure It Out*. He showed me all the cool plants he grows at IBW Enterprises, and he even gave me some to take home. Leo Song at California State University at Fullerton, and Tom Johnson who is in charge of the ICPS seed bank, helped me out and showed me around their greenhouses. I was very excited to see their awesome plants! I borrowed a few of their plants for *The Tonight Show*.

Jay Leno acted like he was scared of the plants, but I told him and the audience that the biggest thing ever eaten by a carnivorous plant was probably a rat. On the show I put one end of a long worm in one trap of a Venus Flytrap. I put two other parts of the same worm into two other traps on the same plants. I said, "Food fight!" Everyone clapped and laughed. I showed Jay a *Nepenthes bicalcarata*. He pretended the plant was eating him. I said, "Oh Puh-lease!" I told Jay about the two thorns that look like fangs under each trap's lid.

At California State Fullerton's greenhouses, where I met Leo Song, I also got to meet Art North. He raises *Nepenthes*. He showed me some great pictures he took of *Nepenthes* on his trips to Mt. Kinabalu in Borneo. My biggest dream is to go to Mt. Kinabalu someday.

I am very lucky that I have met plant growers who are interested in talking to kids about carnivorous plants. I feel very happy when they talk to me and answer my questions. I am a kid with a lot of questions. I have made presentations about my carnivorous plants to other kids in different classes at my school, even kids who are much older than me. I show kids what my carnivorous plants can do, and they love it. I tell them that many carnivorous plants are endangered and should not be collected from the wild. I think it is a good idea to teach kids all about carnivorous plants, because we want kids to learn about nature so they will help preserve it.

Eight-year old Shawn wrote this article with a little help from his mom. ICPS members who attended the 1996 meeting in Atlanta may remember Shawn—he passed around a giant cookie that he and a friend had decorated to look like Drosera erythrorhiza.

Judith Finn on Growing *Pinguicula laueana*

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Keywords: cultivation: *Pinguicula laueana*.

Early in 1998 I had the pleasure of discussing carnivores with Judith Finn, horticulturist at Berkeley Botanical Gardens. I was most interested in how she grows her marvelous specimens of *Pinguicula laueana*. Look at the front cover to see why I am so entranced by this plant!

CPN: I've seen the *Pinguicula laueana* you grow at Berkeley. It is marvelous.
JF: Yes, the red flowers are really nice. *Pinguicula laueana* flowers for about seven months of the year; it's a long bloomer. The foliage is also red and very pretty.
CPN: I see you have them in clay pots. What kind of soil do you use?
JF: I like to use a fine, well-drained mix of sand, peat, and fine pumice or perlite, in a 1:1:1 ratio. Live *Sphagnum* is pretty, but it can overgrow the *Pinguicula*.
CPN: How do you water it?
JF: Keep the soil just moist year-round. *Pinguicula laueana* is shallow-rooted, but you should use a tall pot. This way, during the winter the pot wicks up water but the plant doesn't sit in water all the time. During the summer it can stay in a saucer of water. Use purified water like rainwater or from reverse osmosis.

Figure 1: *P. laueana*, photograph by B. Meyers Rice.

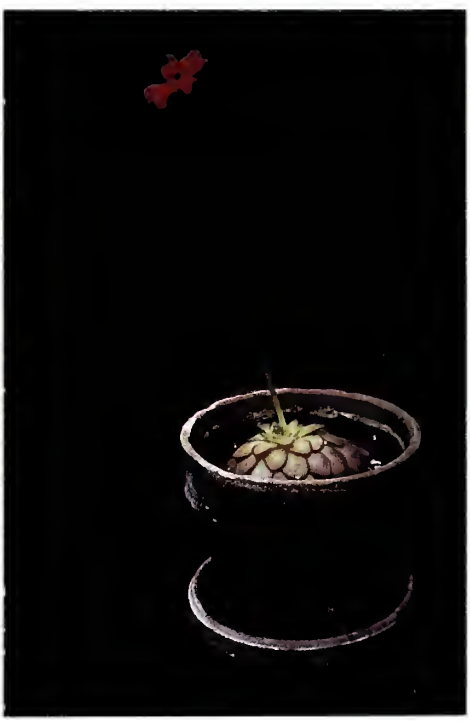

Figure 2: *P. laueana*, photograph by E.M. Salvia.

CPN: You grow your plants in a greenhouse in the San Francisco Bay area, which is generally foggy. Do you need any extra lighting?
JF: This doesn't seem to be too important—we get moderately high light during the summer. During the winter it's more important to supplement the lighting. I use fluorescent bulbs.
CPN: Does this species go dormant?
JF: No, it doesn't seem to go dormant so much as it gets the winter doldrums when the evening temperatures cool down to 55°F (13°C). During the winter it loves temperatures in the 50—60°F (10—16°C) range, but will stand 50—80°F (10—27°C). During the summer it likes 70—80°F (21—27°C), but will take 60—100°F (16—38°C).
CPN: Do you fertilize these? Peter D'Amato accidentally fertilized his with Miracid and ended up killing them (see issue 27:4)!
JF: No fertilizer. Sometimes I give them a little dolomite—lime, that is—or oyster shells. Maybe about a teaspoon (5 cm^3) in a cup of water (250 ml) is enough for a few plants. It also helps keep the *Sphagnum* down, which like I said can crowd the plant.
CPN: Do you have any tips on propagation?
JF: I haven't gotten around to pollinating these, but divisions or leaf cuttings work well. For leaf cuttings, I use summer leaves tucked in live *Sphagnum*.
CPN: Well, you are doing a great job. Do you have any other tricks?
JF: This isn't an exact science! I just grow it like *P. moranensis* and it is alive and happy. It is in the same room as some *Sarracenia*, and they are doing alright. It never has had pest problems. It's a good plant.

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The Biology and Cultivation of Red Australian *Aldrovanda vesiculosa*

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Keywords: cultivation: *Aldrovanda*.

Aldrovanda vesiculosa L. (*Droseraceae*) is an attractive but very rare aquatic carnivorous plant from the Old World. In the last five years, Australians have been trying to grow two "red" strains of *Aldrovanda* endemic to their country (Wilson, 1995; Daly, 1997a, 1997b, 1997c, 1998; Schell, 1997). Among other desirable attributes, these varieties do not require a winter dormancy. In this paper I present notes pertaining to these Australian plants—a more general discussion of *Aldrovanda* can be found elsewhere (cf. Breckpot, 1997; Adamec, 1997).

In Australia, *Aldrovanda* is far less common than it once was, and it is designated a rare and threatened plant. In this article I discuss specimens from a poor site at Girraween Lagoon, approximately 30 km southeast of Darwin (Wilson, 1995), and a swamp near Batemans Bay at the East Coast, approximately 110 km southeast of Canberra (S. Jacobs, personal communication). In contrast with most European sites, dense growths of other aquatic plants grow with *Aldrovanda* at Australian sites (Wilson, 1995; S. Jacobs, personal communication).

Biological particulars

There are four main differences between the European temperate and the Australian (sub)tropical strains of *Aldrovanda* I have studied: the colors of the plants, their overwintering characteristics, the particulars of their of axillary buds, and their different sensitivities to boron. I discuss the first three below. The details of the boron sensitivities are described in the next section.

Color: The European and Japanese plants are light green and contain a great deal of plumbagin (a sulphur-yellow pigment) but no anthocyanins. The color of Australian plants may be the same green, or slightly rose to deep purple (Figure 1) because they contain anthocyanins as well as plumbagin. Irradiance is the main factor regulating the color of the Australian plants—if the plants are exposed to sunshine for at least two hours a day they become red in summer and rose in winter. If grown indoors, supplemental fluorescent lights help the plants become red.

Overwintering Characters: In contrast with the European and Japanese *Aldrovanda*, strains from both Australian sites can grow year round under natural light at a daily temperature of about 18°C or higher (at 18-19°C, the growth is very slow and the plants are in the winter growth form). In an indoor aquarium under natural light, the growth rate of east coast plants in June (spring) is approximately 0.7 new leaf whorls per day. The plants average 23-26 cm long, with 31-35 adult leaf whorls. During the winter, the plants are much shorter (3.3-12.4 cm, 10.5-19 whorls) and their growth rates are only approximately 0.2-0.5 whorls per day.

Even though they may be grown continuously, Australian *Aldrovanda* can be stimulated into producing turions if the plants are subjected to daily temperatures below approximately 18°C (cf. Adamec, 1999). In my outdoor culture, Australian plants started forming turions in early October (autumn), one month later than the temperate strains did. Shoots died very slowly (even at 8-10°C) and were still attached very firmly to the turions. At the end of October, shoots with turions sank to the bottom.

Figure 1: Flowering *Aldrovanda vesiculosa* from north Australia grown in indoor aquarium, September 1998.

Figure 2: *Aldrovanda vesiculosa* from southeast Australia in a 3-liter aquarium, October 1998.

The turions of Australian strains are more weakly dormant than temperate strains are (cf. Adamec, 1999). When plants forming turions were transferred from the Domanínsky wetland to an indoor aquarium at 19-24°C (on 27 September), they immediately resumed growth. However, when Australian strains were transferred from the outdoor culture (6-7°C) to indoors (18-20°C) at the end of October they stayed dormant for several weeks. (It is worthwhile to note that these plants demonstrated interesting characteristics. During the first two weeks, big axillary buds formed on the shoots close to the turions, and new plants started growing from these buds. Thus, the dormancy is only confined to main-shoot turions.) In summary, the turions of north Australian plants were more deeply dormant than those from the east coast, and overall, the Australian strains are not as adapted to cold overwintering as the temperate ones are.

Axillary Buds: Long specimens of Australian plants growing both indoors and outdoors in summer frequently form branches from axillary buds (i.e. 1-6 buds per plant). In contrast, temperate strains form axillary branches poorly, and mainly when their apices are damaged.

In outdoor experiments, both strains of Australian *Aldrovanda* grew and proliferated well from early June to late October 1998 (after Adamec & Tichy, 1997). Plants from north Australia grew vigorously in a nylon enclosure in a shallow dystrophic wetland near Trebon, where Polish *Aldrovanda* had been grown previously (Adamec, 1995). While the doubling time of apices (15.5-26.0 days) was the same as for the Polish *Aldrovanda*, the Australian plants branched much more frequently—branches were formed every 3.3-4.5 leaf whorls, as opposed to approximately every 6 whorls as in the Polish plants. Branch proliferation almost stopped in late August and the plants shortened gradually to approximately 1.8 cm.

How to grow Australian *Aldrovanda*

To grow Australian *Aldrovanda* successfully you must modify the methods that are appropriate for temperate strains (see Adamec, 1997; also Wilson, 1995; Daly, 1997a, 1997b, 1997c, 1998; Schell, 1997). In summary, the Australian strains can be grown outdoors in big containers or small aquaria as normal (Figure 2), from May to October (i.e. spring to autumn), and then transferred to indoor aquaria. Turions can probably overwinter in water in a refrigerator at 3-5°C. It is convenient to grow them indoors in small aquaria (3-20 liter) under natural light at temperatures exceeding 18°C for the whole year. It is the best if the aquaria stand close to an east or southeast oriented window so the plants are irradiated by direct morning sunlight for a few hours each day. This should be supplemented by diffuse light for the rest of the day. A 10-Watt fluorescent lamp can help. Australian *Aldrovanda* tolerate less irradiance but higher temperatures (optimum 25-29°C; maximum 34°C) than do temperate strains. In order to reduce the growth of filamentous algae, the aquarium wall facing the sun should be shaded by a sheet of paper from about 2 cm below the water surface to the bottom. During the summer, the aquarium should be shaded with a sheet of fine paper to keep it cool.

In indoor aquaria, Australian *Aldrovanda* flower richly in summer at 20-29°C. The flower stalks of the Australian ones were red (Figure 1). No flower set seeds, but they do in the wild (S. Jacobs, D. Wilson, personal communication).

Robust sedge or reed litter (i.e., dry dead leaves or straw collected in late winter) is the required substrate. The optimum amount of dry litter is approximately 4±0.5 g per three-liter aquarium. A dose of fresh litter lasts for 2-3 months. The water pH should be 6.0-7.5. A high CO_2 concentration >0.1 mmol/l is necessary for vigorous growth of *Aldrovanda*, and you may wish to add CO_2 to the water (see the

article about CO_2 generators in this issue, on page 132).

As described for temperate *Aldrovanda* (Adamec, 1997) the cultivation water should be rather poor in N and P to control algal growth. In one aquarium, very low concentrations were measured (e.g., in µg/l: PO_4-P, 10.2; NH_4^+-N, 0.0; NO_3^--N, 11.8; NO_2^--N, 6.5). You may add 1-2 small water snails (e.g. *Planorbis*) to a three-liter aquarium, but too many foul the water (Underwood, 1991).

In a previous paper (Adamec, 1997), I described how a disorder commonly exhibited by cultivated *Aldrovanda* was determined to be a boron deficiency. It has been confirmed recently that an addition of 0.05 ml/l of complete microelement solution (see Table I) once or twice a year cures the plants. I have often observed this disorder in the Australian strains, but these plants are rather sensitive to boron—adding 0.5 mg/l of H_3BO_3 can damage them. However, the addition of 0.03-0.05 ml/l of the new, complete microelement solution will cure the plants of this disorder. Symptoms of iron deficiency (yellowish but healthy apices) are suppressed by an addition of 1-2 mg/l of $FeSO_4.7H_2O$ or 2-3 mg/l of Fe-EDTA.

Table I. Composition of the Gaffron microelement solution and final concentrations of salts and elements after an addition of 0.05 ml of the stock solution to one liter of water.

Compound	Stock solution (mg/l)	Final concentration of ... ...the salt (µg/l)	...the element (nmol/l)
H_3BO_3	3100	155	B: 2500
$MnSO_4.4H_2O$	2230	111	Mn: 563
$ZnSO_4.7H_2O$	287	14.4	Zn: 50
$CuSO_4.5H_2O$	125	6.3	Cu: 25
$(NH_4)_6Mo_7O_{24}$	88	4.4	Mo: 26.5
$Co(NO_3)_2.6H_2O$	146	7.3	Co: 25

Acknowledgements: I am very grateful to Dr. Surrey Jacobs and Mr. Denis Daly for sending me the Australian plants of *Aldrovanda* and providing interesting data.

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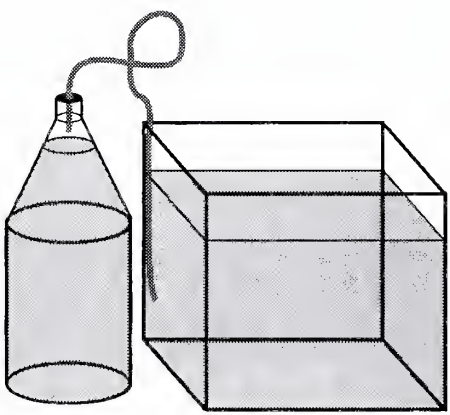
An Economical Carbon Dioxide Generator

Tony Camilleri • PO Box 42853 • Casuarina 0811 • Northern Territory • Australia

Keywords: Cultivation: *Aldrovanda vesiculosa*, carbon dioxide.

In his article, Dr. Adamec mentions that *Adrovanda vesiculosa* appreciates the infusion of carbon dioxide in its water. You can create your own carbon dioxide generator of only a few cents per week. I have been using this method for some time with certainly noticable improvements in the growth rate of *Aldrovanda vesiculosa*.



Equipment required:
Five litre or 1 gallon container with sealed lid,
250 grams or 9 ounces sugar,
1 teaspoon yeast,
A length of hose to reach from the generator to the *Aldrovanda vesiculosa* tank.

Prepare the container by drilling or cutting a hole into the lid. Make the hole large enough so the hose fits snugly into it. Insert the hose into the hole and carefully seal it in place to prevent gas leaks (any sealant, such as silicone, will do). When the container is ready, fill it with three litres of water, then add the sugar and yeast. Seal the lid with the hose attached and submerge the other end of the hose in the *Adrovanda* tank.

Depending on the temperature, the reaction may take up to eight hours to begin. The generator will produce carbon dioxide for up to two weeks. At that point, clean out the generator, add a new mix of water, sugar, and yeast, and it will resume its production of carbon dioxide.

ICPS Seedbank

Tom Johnson, Coordinator•P.O. Box 12281•La Crescenta, CA 91224-0981•USA•
tom@carnivorousplants.org•http://www.primenet.com/~tjjohns/seed.htm

Darlingtonia californica
D. californica—Josephine Co., Oregon
D. californica—Nevada Co., California
D. burmannii—Beerwah, Queensland
D. burmannii—giant form, Mann River
D. capensis—green
D. capensis—narrow leaf
D. capensis—purple flower
D. capensis—red
D. capensis—white flower
D. capillaris
D. filiformis var. *filiformis*—North Carolina
D. filiformis var. *filiformis*—New Jersey pine barrens
D. filiformis var. *filiformis*—Manchester, New Jersey
D. intermedia—Carolina giant form
D. rotundifolia—Mendocino Co., California
D. rotundifolia—Nevada Co., California
D. rotundifolia—Manchester, New Jersey
D. stenopetala
Sarracenia flava
S. flava—Ben Hill Co., Georgia
S. flava—Fitzgerald, Ben Hill Co., Georgia
S. flava—Hampstead, North Carolina
S. leucophylla
S. minor—Fitzgerald, Ben Hill Co., Georgia
S. purpurea subsp. *purpurea*
S. purpurea subsp. *purpurea*—north Ohio plains
S. purpurea subsp. *purpurea*—Manchester, NJ × *S. purpurea* subsp. *venosa*—Hampstead, North Carolina
S. minor & *psittacina*—Fitzgerald, Ben Hill Co., Georgia, seeds mixed

Miscellaneous noncarnivores:
Ibicella lutea—5 seeds per packet
Mimosa pudica—sensitive plant

All seed contributions are gratefully accepted. You must use bubble wrap to protect the seeds from shipping damage.

The seed bank listing is only an approximation to the current seed bank inventory. Before ordering any seed you should request an updated listing from Tom Johnson (the Seed Bank Coordinator). A plant followed by an entry in parentheses means there are a limited number of seed packets remaining.

All orders and correspondence with the seed bank must be accompanied by a self addressed, stamped envelope. Postage is $.33 for a seed list, $.55 when ordering seed. Seed costs $1 per packet. IRCs are accepted. You should specify alternative seeds with each order in case your first choices are no longer in stock.

Looking Back: CPN 25 years ago

In a report on Michigan and Ontario fens, Schnell and Sivertsen described the peculiar situation regarding the ancestry of *D. anglica*: "An extreme interpretation of this data would be to declare all *D. anglica* as fertile hybrid, and indeed Wagner suggests designating the plant as *D.* × *anglica* with sterile and fertile forms and not giving it specific status at all. So the *Droseras* [*sic*] in this little marl bog have presented us with a real series of problems and we will be some time untangling the situation." Some time, indeed! Twenty-five years later, on page 107 of the issue you are now reading, Don Schnell is publishing his latest contribution to untangling the *D. anglica* mystery.

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Species/Hybrid Name	Native Area, Description Leaf Size in Inches	US $
C. follicularis	Australia (3/4") (2 plants)	13
H. heterodoxa	Gran Sabana, Venezuela (4")	80
H. ionasi	Ilu Tepui., Venezuela (1.5")	65
H. minor	AuyanTepui, Venezuela (4")	80
H. minor	Akopan Tepui, Venezuela, hairy, (4")	80
H. nutans	C. Kukenam, Venezuela (1.5")	30
H. tatei	C. Huachamachari, Venezuela (2")	65
N. alata	Palawan, Philippines (3")	20
N. alata	Philippines (dark red traps, 4")	40
N. albo-marginata	Penang, Malaysia (green trap, 3")	22
N. albo-marginata	Penang, Malaysia (red trap, 2")	35
N. ampullaria	Sarawak, Malaysia (green, 4")	27
N. ampullaria	Sarawak, Malaysia (speckled, 4")	35
N. ampullaria	Sipitang, Borneo (4")	20
N. aristolochioides	Sumatra (1")	59
N. bellii	Mindanao, Philippines (2")	38
N. bicalcarata	Borneo (4")	45
N. bongso	G. Talang, Indonesia (2")	50
N. burbidgeae	G. Kinabalu, Sabah (2")	89
N. burkei	Philippines (3")	25
N. caranculata	G. Sago, Sumatra (2")	35
N. clipeata	G. Kelam, Borneo (3")	80
N. danseri	Waigeo Island, Irian Jaya (4")	40
N. deaniana	Palawan (2")	50
N. distillatoria	Sri Lanka (1")	39
N. ephippiata	G. Raya, Borneo (2")	45
N. eustachya	K. Sembilan, Sumatra (3")	55
N. eymae	G. Lumut, Sulawesi, Indonesia (1")	60
N. fusca	Sabah (2")	30
N. gracilis	Talangka Rajah, Borneo (3")	15
N. gracillima	Genting Highlands, Malaysia (2")	40
N. gymnamphora	G. Singgalang, Sumatra (1")	40
N. hirsuta	Sarawak, Malaysia (1")	35
N. hispida	Malaysia (4")	45
N. insignis	E. Biak, Indonesia (3")	50
N. khasiana	Meghalaya, India (2")	15
N. lamii	Irian Jaya (2")	50
N. lowii	Brunei (1")	50
N. lowii	G. Mulu, Sarawak (1")	50
N. lowii	G. Trusmadi, Sabah (2")	50
N. lowii	G. Murud, 6400 ft (1")	50
N. lowii	G. Kinabalu, Sabah (1")	75
N. macfarlanei	Genting Highlands, Malaysia (2")	30
N. macrophylla	G. Trusmadi, Borneo (3/4")	80
N. macrovulgaris	G. Silam, Sabah, Malaysia (1")	35
N. madagascariensis	Madagascar (2")	15
N. maesolensis	Madagascar (1")	30
N. maxima	Rantepao, Sulawesi (2")	30
N. maxima	Celebes (2")	30
N. maxima	Anggi Lakes, Irian Jaya (2")	35
N. maxima	G. Cobray, 7260 ft. (1")	40
N. maxima	Indonesia (4")	45
N. merrilliana	Philippines (2")	35

Species/Hybrid Name	Native Area, Description Leaf Size in Inches	US $
N. mirabilis	Cape York, Australia (2")	15
N. mirabilis	Brunei (Echinostoma, 3")	45
N. muluensis	G. Mulu, Sarawak (2")	60
N. murudensis	G. Murud, 7000 ft. (2")	60
N. neogunieensis	Angkasa, Irian Jaya (3")	60
N. northiana	Bau, Sarawak (3")	50
N. pectinata	G. Singalang, Sumatra (2")	70
N. pervillei	Seychelles (2")	40
N. pilosa	G. Batu Buli, Sarawak (1")	35
N. rafflesiana	Malaysia (green traps, 4")	15
N. rafflesiana	Sandakan (2")	40
N. rajah	G. Kinabalu, Sabah (1")	40
N. ramispina	G. Ulu Kali, Malaysia (1")	25
N. reinwardtiana	Borneo (green trap, 2")	20
N. reinwardtiana	Telupid, Sarawak (red trap, 2")	30
N. reinwardtiana	G. Murud, 6900 ft. (1")	40
N. sanguinea	Genting Highlands, Malaysia (3")	20
N. spathulata	Sumatra (2")	60
N. stenophylla	Sarawak (2")	60
N. sumatrana	Sibolga, Sumatra (3")	40
N. tentaculata	G. Kinabalu, Sabah (1")	30
N. tentaculata	G. Murud (1")	30
N. thorelli	Phuk Radung, E. Thailand (3")	30
N. tobaica	Sumatra (red pitcher) (3")	35
N. tomoriana	Sulawesi (1")	45
N. treubiana	Sibolga, Sumatra (3")	40
N. truncata	Philippines (4")	40
N. veitchii (highland)	Batu Lawi, Sarawak (3")	45
N. veitchii (lowland)	Sungai Samba, Borneo (3")	40
N. ventricosa	Philippines (4")	15
N. ventricosa	Philippines (green traps with dark red peristome, very unusual, 4")	35
N. vieillardii	New Caledonia (2")	30
N. villosa	G. Kinabalu, Sabah (3/4")	60
Selected Hybrids		
N. bicalcarata x ampullaria	Sipitang, Sabah (very vigorous with dark red/green leaves, 3")	30
N. bongso x maxima	(3" leaves	50
N. fusca x burbidgeae	(2" leaves)	45
N. x hookeriana	Peninsular Malaysia (3")	45
N. khasiana x truncata	(3" leaves)	40
N. sanguinea x truncata	(2" leaves)	40
N. spathulata x veitchii	(2" leaves)	40
N. truncata x maxima	(4" leaves)	40
N. truncata x ventricosa	(4" leaves)	40
N. veitchii x lowii	(3" leaves)	40
N. ventricosa x inermis	(4" leaves)	40
Victorian Hybrids	Spectacular Traps (>4" leaves)	
N. x chelsonii	London, Late 1800's	25
N. x coccinea	London, Late 1800's	25
N. x dyeriana	London, Late 1800's	50
N. x edinensis	London, Late 1800's	25
N. x mixta	London, Late 1800's	30
N. x wrigleyana	London, Late 1800's	25

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Referees

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